An Appraisal of Emerging Bluetooth Traffic Survey Technology

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Abstract

The A77(T) trunk road provides a lifeline link for south west Scotland, passing through communities of Lendalfoot, Ballantrae, Cairnryan and Stranraer. The road also acts as the strategic link for the ferry ports at Stranraer and Cairnryan.

In November 2011, ferry operator Stena Line relocated their North Channel services from Stranraer to a new purpose built terminal at Old House Point, Cairnryan. The move has allowed Stena to operate larger but more economical ferries.

Transport Scotland engaged consultants SIAS Ltd and Sky High Traffic Surveys to collect evidence to determine any change in traffic patterns as a result of Stena's move to Old House Point.

Unlike more traditional survey techniques for capturing origin-destination movements, Transport Scotland opted for Bluetooth survey techniques, an emerging technology for traffic surveys.

In the Autumn of 2011, Bluetooth signal data was collected at nine locations on the A75(T) and A77(T) to capture the distribution of trips to and from the Stranraer and Cairnryan ferry ports. The surveys were repeated in early 2012, with a station established at the new terminal at Old House Point.

At each Bluetooth station, a classified ATC counter was installed to determine the sample size and classification of passing traffic. Classified video surveys were also established at each ferry port to record the classification of each vehicle entering or leaving the ports.

Together, the data provides origin-destination and vehicle classification data for a sample of the ferry port traffic. Unlike disruptive Roadside Survey Interview (RSI) techniques, Bluetooth technology is unobtrusive and can collect data for much longer periods, even overnight.

This paper outlines Transport Scotland's requirements, the scope of the survey programme, how Bluetooth technology was employed and a summary of the initial survey results.

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1. Introduction

The A77(T) trunk road provides a lifeline link for south west Scotland, passing through communities of Lendalfoot, Ballantrae, Cairnryan and Stranraer. The road acts as the strategic link for the ferry ports at Stranraer and Cairnryan.

In November 2011, ferry operator Stena Line relocated their North Channel services from Stranraer to a new purpose built terminal at Old House Point, Cairnryan. The move has allowed Stena to operate larger but more economical ferries.

The other ferry operator, P&O, continue to operate their passenger and freight operations from a separate port on Loch Ryan, at Cairnryan.

Transport Scotland engaged consultants SIAS Ltd and Sky High Traffic Surveys to collect evidence to determine any change in traffic patterns as a result of Stena's move to Old House Point.

This paper outlines Transport Scotland's requirements, the scope of the survey programme, how Bluetooth technology was employed and a summary of the initial survey results.

In addition to capturing changes in traffic movements, the data will also be used to help define vehicle trip length distributions within a route model of the A77.

2. Transport Scotland Survey Requirements

2.1 General

SIAS Limited (SIAS) was commissioned by Transport Scotland (TS) to carry out traffic surveys on the A77(T) as part of a fundamental review of the A77(T) route strategy. Several road improvement schemes have been implemented on the A77(T), including:

- A77(T) Park End scheme (2011)
- A77(T) Haggstone Climbing Lane scheme (2009)
- A77(T) Glen App scheme (2009)

Further schemes are planned for the route. These will be brought forward as funding is made available. Meantime, ferry operator Stena Line has relocated its North Channel services from Stranraer to a new Ferry Terminal at Old House Point. The other North Channel ferry operator, P&O, continue to operate from their separate port at Cairnryan.

As part of an overall review of the improvement schemes still in development, and in consultation with both ferry operators, TS required an understanding of how the route is operating following Stena's move to Old House Point.

As well as quantifying the change in traffic patterns on the route, the information will be fed into an updated microsimulation traffic model of the route which will be used to assess the economic viability of the remaining road schemes.

2.2. Survey Techniques

Traditionally, Automatic Number Plate Recognition (ANPR) surveys would be undertaken to collect origin destination data.

However, recent developments in survey techniques and in particular the increasing use of wireless technology led TS to trial the use of Bluetooth traffic survey techniques.

A limited number of survey companies are now offering Bluetooth capability, with Sky High Traffic Surveys PLC (Sky High) being amongst the first to invest in this new technology.

2.3 What is Bluetooth?

Bluetooth technology provides the ability to track devices through a network by working on the principle of matching the Migration Access Code (MAC) addresses from each Bluetooth device. The MAC code is a 17-18 digit address unique to each phone, hands-free kit, satellite navigation system or any other Bluetooth device.

Bluetooth scanners are mounted on suitable items of street furniture and each unit is set up and calibrated at the roadside. Site data from each scanner is then uploaded by GPRS to a web hosted server where it can be manually downloaded at a later point in time.

Further details are provided in Chapter 4.

3. Scope of Traffic Surveys

3.1 General

The following traffic surveys were undertaken by Sky High in November 2011 on the A77(T) and A75(T) routes.

- Bluetooth Scanning Device surveys
- Classified Link Counts (using ATC loops)
- Video Surveys

The surveys were carried out to provide a 'reference case' or baseline against which the changes in travel patterns as a result of relocation of the Stena ferry operation can be assessed.

The surveys were repeated in February 2012, but at the time of writing, the results of the 'after' surveys are still being processed. Consequently, this paper is confined to reporting the outcome of the 'baseline' surveys.

The study area is shown in Figure 3.1 below.

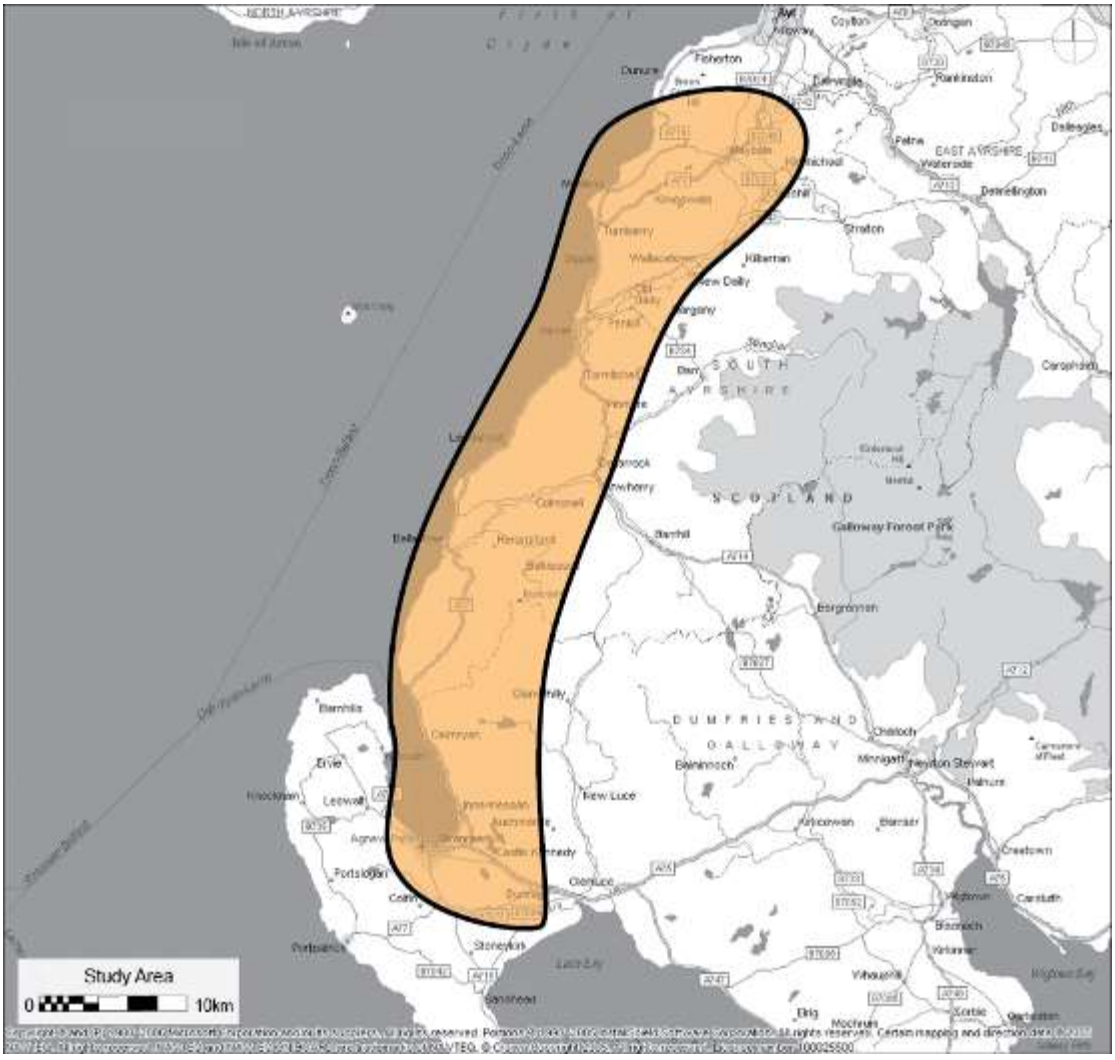

Figure 3.1: Extent of Study Area

3.2 Bluetooth Surveys

Bluetooth surveys were carried out for a seven day period commencing Saturday 5th November 2011 and finishing Friday 11th November 2011. The surveys were carried out at six locations in the study area.

Bluetooth MAC data was collected at six locations within the study area:

- A717 Stranraer Ferry Port – Car Entrance
- A717 Stranraer Ferry Port – HGV/Caravan Entrance
- A75(T) – Castle Kennedy
- A77(T) Cairnryan Ferry Port – All Vehicles Entrance
- A77(T) South of Glendoune Street/A714/A77(T) Roundabout
- A77(T) – North of Maybole

The location of each Bluetooth survey station is illustrated In Figure 3.2 below.

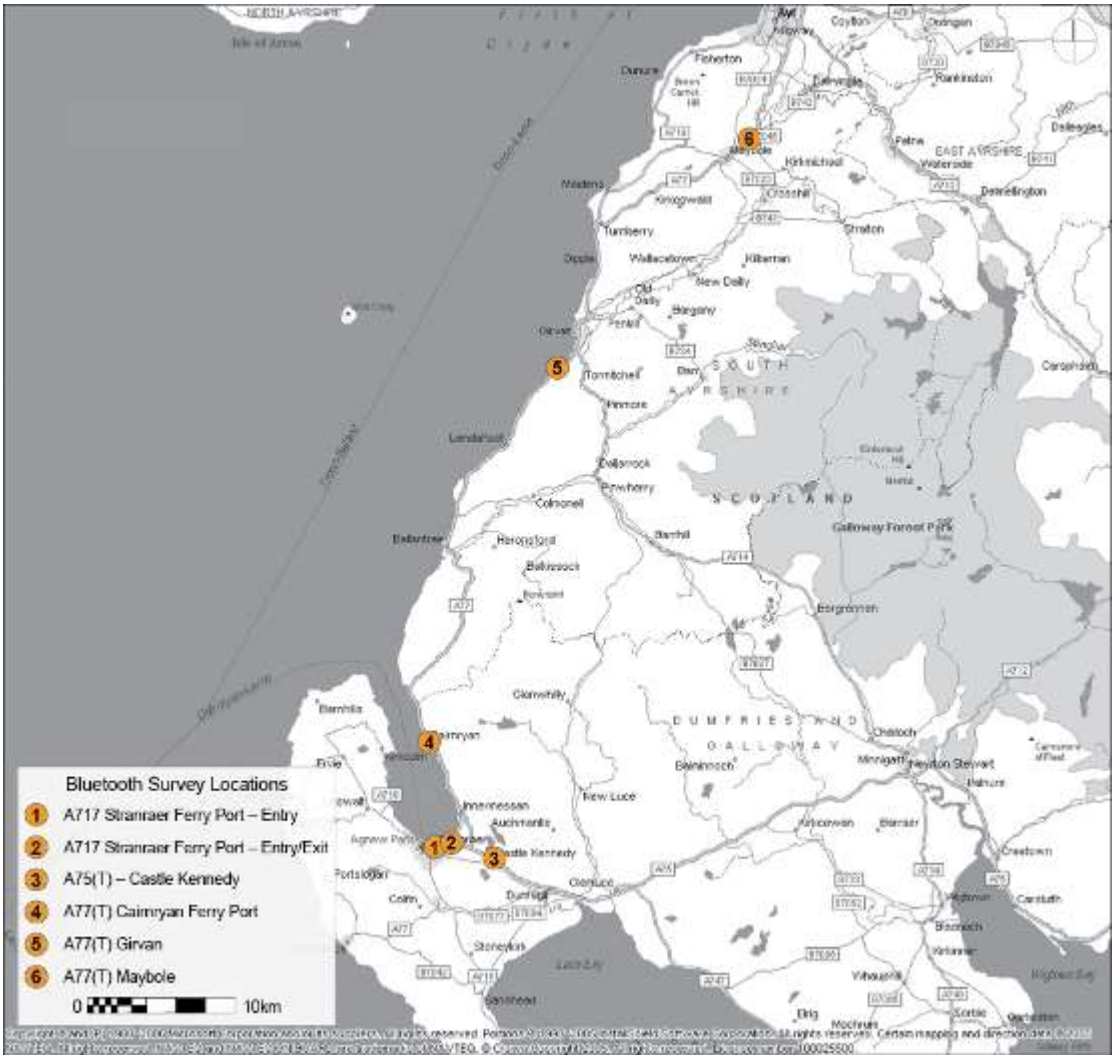

Figure 3.2: Bluetooth Survey Station Locations

3.3 Classified Link Count Surveys

Classified link count surveys were also undertaken using TS permanent site Automatic Traffic Count (ATC) loop counters at three locations. Classified link count data was extracted for a 24hr period at the following locations.

- A75(T) West of Newton Stewart (JTC00377)
- A77(T) South of Girvan (JTC00366)
- A77(T) North of Maybole (ATC08523)

3.4 Video Surveys

Video surveys were undertaken at the entrance and exit points at both the Stranraer and Cairnryan ferry ports. Both ports were surveyed for a 24hr period on Wednesday 9th November 2011 but, due to a problem with the video camera the entrance / exit at Cairnryan ferry port, the junction was resurveyed on Friday 11th November 2011.

In surveying the Stranraer ferry port access / egress, it should be noted that the port has two entry points; one for cars and the other for heavy goods vehicles. The Cairnryan ferry port however has only one entry/exit point for all vehicles.

4. How Bluetooth Technology was Employed

4.1 General

In response to a need for a more cost effective and reliable method for collecting vehicle (and pedestrian) origin-destination and journey time data, Sky High has developed a system using portable scanners to detect and store signals from passing Bluetooth devices. The results are collated and reported using a web-based data analysis and reporting tool.

4.2 Principles of Bluetooth Capture

The principles of the system are based around being able to detect and store with a date and time stamp the unique identification code (the 'MAC address') transmitted by the Bluetooth chip within a device. Devices which contain Bluetooth chips include mobile phones, hands-free audio kits, laptops and in-vehicle electronics/engine management systems.

The presence of traceable Bluetooth devices on persons and in vehicles is increasing all the time and even some entry level vehicles for example, are now sold with "Bluetooth as standard". Even if an in-car Bluetooth system is not connected to a mobile phone, once the ignition is switched on, the built in chip will be transmitting the unique MAC address.

4.3 Data Protection

To date, confidentiality and data protection has not been an issue with Bluetooth capture in the UK. The device chip cannot be linked to the SIM card/phone number in a mobile phone. In addition, the system used by Sky High also encrypts the MAC addresses on detection, assigning each record a unique identifier.

4.4 Installation and Operation

The equipment continuously scans over a controllable and defined detection zone and stores device address and device type data to the nearest second. The user-defined 'Device name' is not stored. One scanner can detect over multiple lanes and is not affected by weather, traffic speed (high or low) or mobile phone signal coverage. The scanners are weatherproof, have a minimum 12 day battery life and have an on-board GPRS modem for data upload and to allow live technical checks on system operation. Local data storage as back-up is also a feature. The scanners can be fixed to various items of street furniture using steel or plastic banding or a free standing mast and installations typically take in the region of 20 minutes per site allowing for set up and calibration.

Two example sensor installations are shown below:

Figure 4.1: Typical Bluetooth Sensor Installations

Data is transmitted from site at intervals (typically twice per day) to the Sky High web database through which various site monitoring and data analysis reports can be produced. The system has sophisticated algorithms built in to match MAC addresses between points, along routes and across areas and to account for multiple devices in one vehicle.

The system features a *Google* maps interface and various date/time and filtering parameters can be set to allow specific reports to be generated including origin-destination matrices, journey time analyses and point-to-point linkages. Data sets can also be exported to Excel for further analysis.

A sample screenshot is provided below in Figure 4.2.

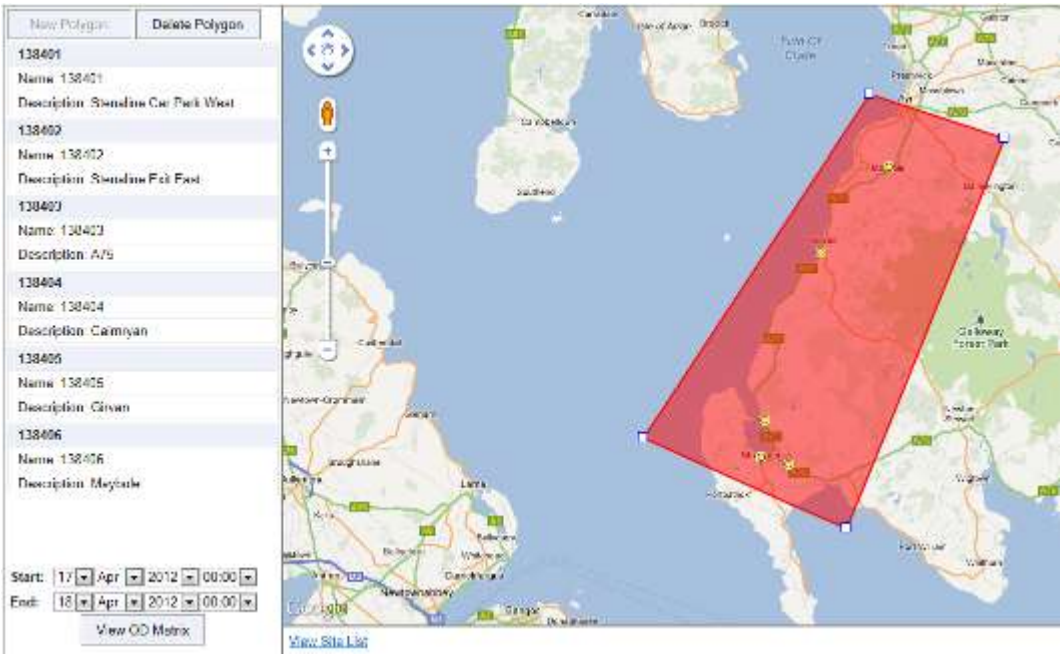

Figure 4.2: Sample Screenshot from Web-Based Analysis Tool

5. Survey Results

5.1 General

As indicated above, the results of the surveys can be easily interpreted from the web based analysis and reporting tool. The user can manipulate and derive origin-destination or travel time data for discrete time periods.

However, for the specific nature of the A77(T) surveys, Sky High were able to provide the raw datasets to SIAS for further interrogation.

5.2 Sample Rates

The raw Bluetooth MAC data as output from each scanning device was supplied to SIAS. The total number of records collected at each of the six sites is detailed below in Table 5.1.

Table 5.1: Total Number of Bluetooth Signatures Captured

		Total No. of Bluetooth Records							
Site	**Site No.**	**Sat 05/11/11**	**Sun 06/11/11**	**Mon 07/11/11**	**Tue 08/11/11**	**Wed 09/11/11**	**Thu 10/11/11**	**Fri 11/11/11**	***Total***
Stranraer (West)	1	316	276	344	275	292	338	342	*2,183*
Stranraer (East)	2	632	732	761	825	753	828	863	*5,394*
A75 Castle Kennedy	3	1,481	1,330	2,160	2,137	2,283	2,381	2,260	*14,032*
Cairnryan	4	648	642	844	964	918	1,097	1,121	*6,234*
Girvan	5	1,590	1,507	1,856	1,640	1,693	1,968	1,927	*12,181*
Maybole	6	3,255	3,138	4,072	3,883	4,046	4,303	4,374	*27,071*
Total		*7,922*	*7,625*	*10,037*	*9,724*	*9,985*	*10,915*	*10,887*	

The Bluetooth scanner at Maybole (Site 6) shows the greatest number of signatures compared with the other sites. Both Stranraer West (Site 1) and Stranraer East (Site 2) reflect the operation of the Stranraer Ferry Port: Stranraer West is an entrance for cars only to the ferry port; Stranraer East is an entrance for heavy goods vehicles and caravans. The Stranraer East site provides an exit for all vehicles from the ferry port.

The Stranraer West site, although an entry to the ferry port for cars only, also includes a general car park for Stranraer town centre. Consequently, it is possible for vehicles to enter and exit the Stranraer West site.

The number of records that were subsequently matched at other sites is summarised in Table 5.2 below for Wednesday 9th November 2011 (the day that video surveys were undertaken at Stranraer).

Table 5.2: Sample Size

Wed 9 Nov 2011 Data Sets

Site	24-Hr Count Data (Veh)	24-Hr Bluetooth Records	Sample Size (%)	24-Hr Bluetooth Records Matched	Sample Size (%)
Stranraer (West)	580	292	50%	92	16%
Stranraer (East)	1,514	753	50%	369	24%
A75 Castle Kennedy	4,363	2,283	52%	691	16%
Cairnryan	1,766	918	52%	634	36%
Girvan	3,227	1,693	52%	712	22%
Maybole	10,495	4,046	39%	947	9%
Average			49%		21%

Table 5.2 suggests that when based on the number of signatures collected at each site, the sample size is between 39% and 52%, with an average of 49%. If the sample size is then based upon the number of records that were subsequently matched, the range is between 9% and 36%, with an average value of 21%.

5.3 Derivation of Origin Destination Matrix

The average weekday, weekend and 7-day Origin and Destination totals for matched records are presented in Tables 5.3 to 5.5 below.

When interpreting the tables, it should be recognised that records for Site 1, Site 2 and Site 4 can more readily be attributed as trips to or from the ferry ports. The scanners were located at the entry/exit points to the ports. In the case of Site 3, Site 5 and Site 6 the scanners are simply located on the A77(T)or A75(T). Consequently, the specific origin or destination beyond these points is unknown (unless it is one of the ferry ports).

The results of the 24 hour Bluetooth Surveys (Matched Records) – Weekday Average are shown in Table 5.3 below.

Table 5.3: Matched Records – Weekday Average

24hr Bluetooth Survey - Site OD Matrix (Veh)

Weekday Average	Stranraer (West)	Stranraer (East)	A75 Castle kennedy	Cairnryan	Girvan	Maybole	***Total***
Stranraer (West)	2	24	7	2	1	2	***39***
Stranraer (East)	17	0	125	6	13	67	***226***
A75 Castle Kennedy	23	95	2	177	21	29	***347***
Cairnryan	1	5	164	0	24	96	***289***
Girvan	3	13	26	22	1	317	***381***
Maybole	19	40	30	93	309	2	***493***
Total	***65***	***177***	***353***	***300***	***368***	***511***	***1775***

The results of the 24 hour Bluetooth Surveys (Matched Records) – Weekend Average are shown in Table 5.4 below.

Table 5.4: Matched Records – Weekend Average

24hr Bluetooth Survey - Site OD Matrix (Veh)

Weekend Average	Stranraer (West)	Stranraer (East)	A75 Castle kennedy	Cairnryan	Girvan	Maybole	*Total*
Stranraer (West)	2	23	5	2	1	4	***35***
Stranraer (East)	12	0	95	4	22	76	***208***
A75 Castle Kennedy	25	75	2	104	10	23	***238***
Cairnryan	1	4	91	0	14	70	***179***
Girvan	8	18	12	26	0	231	***294***
Maybole	16	42	21	60	237	2	***376***
Total	***62***	***160***	***226***	***196***	***282***	***403***	***1328***

The results of the 24 hour Bluetooth Surveys (Matched Records) – 7 Day Average are shown in Table 5.5 below.

Table 5.5: Matched Records – 7-day Average

24hr Bluetooth Survey - Site OD Matrix (Veh)

7-Day Average	Stranraer (West)	Stranraer (East)	A75 Castle kennedy	Cairnryan	Girvan	Maybole	*Total*
Stranraer (West)	2	24	7	2	1	3	***38***
Stranraer (East)	15	0	116	5	15	69	***221***
A75 Castle Kennedy	24	89	2	156	18	27	***316***
Cairnryan	1	5	143	0	21	88	***257***
Girvan	5	14	22	23	0	292	***356***
Maybole	18	40	27	84	289	2	***460***
Total	***64***	***172***	***316***	***270***	***344***	***480***	***1647***

The results provide a comparison between the number of matched records and the total number of Bluetooth signatures identified at each site location.

For example, the total number of Bluetooth signatures recorded on Wednesday 9th November 2011 (all sites) was 9,985 (Table 5.1). By comparison, the total number of matched records for the average weekday is 1,775 (Table 5.3). This equates to a sample of around 18% of the total number of records being matched.

To some extents, the number of matched records is influenced by the definition of the survey cordon. The more robust the cordon, the greater the chance of being able to match the records.

5.5 Bluetooth Average Journey Time Data

As part of the matching process of the raw data, a journey time validity trip matrix was developed to help filter the data further and return only records that travelled within permitted time limits between each site. The journey time validity matrix adopted for this study is detailed below in Table 5.6.

Each value adopted was derived by assessing typical journey times between each location using a combination of internet based resources and journey time information.

Table 5.6: Journey Time Validity Trip Matrix

Journey Time Validity Matrix (hh:mm:ss)

Site	Stranraer (West)	Stranraer (East)	A75 Castle Kennedy	Cairnryan	Girvan	Maybole
Stranraer (West)	00:00:00	00:05:00	00:12:00	00:20:00	00:50:00	01:30:00
Stranraer (East)	00:05:00	00:00:00	00:12:00	00:15:00	00:50:00	01:30:00
A75 Castle Kennedy	00:12:00	00:12:00	00:00:00	00:20:00	01:00:00	01:30:00
Cairnryan	00:20:00	00:15:00	00:20:00	00:00:00	00:40:00	01:00:00
Girvan	00:50:00	00:50:00	01:00:00	00:40:00	00:00:00	00:30:00
Maybole	01:30:00	01:30:00	01:30:00	01:00:00	00:30:00	00:00:00

Using the validity matrix as a guide, the average journey times for matched records between each Bluetooth site were calculated as part of the matching process. The average weekday, average weekend and average 7 day journey time results between each site are presented in Tables 5.7 to 5.9 below.

Table 5.7: Journey Times - Weekday Average

24hr Bluetooth Survey - Site JT Matrix (hh:mm:ss)

Weekday Average	Stranraer (West)	Stranraer (East)	A75 Castle kennedy	Cairnryan	Girvan	Maybole
Stranraer (West)	00:00:00	00:02:10	00:07:10	00:10:51	00:41:26	01:02:20
Stranraer (East)	00:02:25	00:00:00	00:06:56	00:10:45	00:41:28	01:04:37
A75 Castle Kennedy	00:07:25	00:06:33	00:00:00	00:09:10	00:43:25	01:06:53
Cairnryan	00:11:55	00:09:15	00:09:33	00:00:00	00:33:09	00:55:27
Girvan	00:40:47	00:40:58	00:43:59	00:33:18	00:00:00	00:23:03
Maybole	01:00:34	01:01:55	01:06:38	00:56:00	00:23:12	00:00:00

Table 5.8: Journey Times – Weekend Average

24hr Bluetooth Survey - Site JT Matrix (hh:mm:ss)

Weekend Average	Stranraer (West)	Stranraer (East)	A75 Castle kennedy	Cairnryan	Girvan	Maybole
Stranraer (West)	00:00:00	00:02:30	00:07:22	00:09:59	00:38:55	00:58:54
Stranraer (East)	00:01:58	00:00:00	00:06:50	00:09:35	00:40:11	01:02:49
A75 Castle Kennedy	00:06:51	00:06:03	00:00:00	00:09:21	00:39:05	01:00:39
Cairnryan	00:07:45	00:09:47	00:09:26	00:00:00	00:31:48	00:53:37
Girvan	00:40:18	00:39:53	00:40:19	00:32:25	00:00:00	00:21:47
Maybole	00:57:13	01:00:23	01:01:47	00:55:08	00:22:14	00:00:00

Table 5.9: Journey Times – 7-Day Average

24hr Bluetooth Survey - Site JT Matrix (hh:mm:ss)

7-Day Average	Stranraer (West)	Stranraer (East)	A75 Castle kennedy	Cairnryan	Girvan	Maybole
Stranraer (West)	00:00:00	00:02:15	00:07:12	00:10:42	00:40:15	01:00:58
Stranraer (East)	00:02:18	00:00:00	00:06:54	00:10:23	00:41:03	01:04:03
A75 Castle Kennedy	00:07:15	00:06:26	00:00:00	00:09:12	00:42:32	01:05:22
Cairnryan	00:10:40	00:09:23	00:09:31	00:00:00	00:32:51	00:55:02
Girvan	00:40:38	00:40:39	00:43:19	00:33:06	00:00:00	00:22:45
Maybole	00:59:46	01:01:28	01:05:33	00:55:50	00:22:59	00:00:00

The average hourly journey times from the Stranraer and Cairnryan ferry ports to and from all other sites is summarised below in Tables 5.10 to 5.12.

Table 5.10: Journey Times - From Stranraer and Cairnryan Ferry Ports

	From Stranraer			From Cairnryan		
Start Hour (hh:mm)	**To A75 (hh:mm:ss)**	**To Girvan (hh:mm:ss)**	**To Maybole (hh:mm:ss)**	**To A75 (hh:mm:ss)**	**To Girvan (hh:mm:ss)**	**To Maybole (hh:mm:ss)**
00:00	00:07:00	-	-	00:09:09	-	-
01:00	00:05:51	-	01:11:10	00:11:49	-	-
02:00	00:05:54	00:40:22	01:01:28	00:08:24	00:32:00	00:52:14
03:00	00:07:33	-	-	00:14:21	00:32:15	00:51:47
04:00	00:07:17	-	-	00:08:07	-	-
05:00	-	00:37:39	00:57:40	00:14:31	00:34:28	00:53:41
06:00	-	-	-	00:09:41	00:36:00	00:59:16
07:00	00:06:40	-	01:18:31	00:12:04	00:35:42	00:58:34
08:00	00:05:43	00:45:32	01:13:05	-	00:37:51	01:01:09
09:00	00:08:38	00:44:06	01:12:47	00:09:20	-	-
10:00	00:06:45	00:38:43	01:00:48	00:08:42	00:35:06	00:56:27
11:00	00:06:35	00:44:23	01:06:04	-	-	-
12:00	-	-	-	00:09:15	00:32:25	00:53:15
13:00	00:06:39	-	-	-	00:33:53	00:57:40
14:00	00:08:20	00:39:43	01:02:51	-	-	-
15:00	-	-	01:05:38	00:08:58	00:31:21	00:55:02
16:00	00:07:37	-	01:09:54	00:07:33	00:33:05	00:54:23
17:00	00:07:35	-	-	00:12:12	00:34:12	00:57:17
18:00	-	00:43:11	01:05:26	00:09:08	00:34:11	00:56:21
19:00	-	-	-	00:09:23	00:34:08	00:56:27
20:00	-	00:44:14	01:12:56	-	-	00:59:20
21:00	00:08:28	-	-	00:06:37	00:33:15	00:54:05
22:00	00:06:19	00:37:01	00:58:30	00:08:31	00:34:25	00:55:25
23:00	-	00:44:48	01:06:51	-	-	-

Table 5.11: Journey Times - To Stranraer and Cairnryan Ferry Ports

	To Stranraer (East)			To Cairnryan		
Start Hour (hh:mm)	**From A75 (hh:mm:ss)**	**From Girvan (hh:mm:ss)**	**From Maybole (hh:mm:ss)**	**From A75 (hh:mm:ss)**	**From Girvan (hh:mm:ss)**	**From Maybole (hh:mm:ss)**
00:00	00:04:42	-	-	00:08:30	00:28:46	00:48:22
01:00	00:06:15	-	00:59:05	00:08:39	00:32:08	00:52:53
02:00	00:05:21	00:38:04	-	00:08:32	00:29:56	00:51:14
03:00	00:04:50	-	-	00:08:36	00:31:36	-
04:00	-	-	-	00:07:24	-	00:51:22
05:00	00:13:27	00:38:38	00:56:59	00:08:06	00:31:11	-
06:00	00:05:38	-	-	00:08:52	00:32:35	00:52:12
07:00	00:06:26	-	01:07:06	00:09:23	-	-
08:00	00:06:00	-	-	00:08:14	00:32:16	00:56:29
09:00	-	-	-	00:09:49	00:31:53	00:53:57
10:00	00:14:54	00:42:57	01:06:28	00:08:48	00:30:38	-
11:00	00:07:16	00:43:39	01:03:20	00:09:46	00:33:38	00:58:00
12:00	00:06:25	00:42:01	01:07:14	00:09:54	00:35:00	00:58:55
13:00	00:07:29	00:42:47	-	00:08:41	00:35:55	00:55:25
14:00	00:06:28	00:43:55	01:06:36	00:11:09	00:34:12	01:02:17
15:00	00:07:26	-	-	00:08:18	00:34:41	00:56:21
16:00	00:06:15	00:47:30	01:08:13	00:08:03	00:33:32	00:58:35
17:00	00:07:01	00:43:38	01:05:27	-	00:35:03	01:01:50
18:00	00:07:18	00:44:52	01:09:02	00:09:20	00:36:16	00:59:04
19:00	00:05:16	00:40:00	01:03:09	00:09:15	00:33:30	00:52:42
20:00	00:05:31	00:39:49	00:56:16	00:09:35	00:33:20	00:57:09
21:00	00:05:23	00:37:31	00:59:47	00:08:23	00:32:08	00:56:02
22:00	00:05:46	00:44:27	-	00:08:47	00:35:16	00:57:03
23:00	-	-	-	00:08:33	00:31:32	00:52:00

Table 5.12: Journey Times – To Stranraer (West) Ferry Port

	To Stranraer (West)		
Start Hour (hh:mm)	From A75 (hh:mm:ss)	From Girvan (hh:mm:ss)	From Maybole (hh:mm:ss)
00:00	-	-	-
01:00	-	-	01:01:03
02:00	00:05:12	00:40:17	-
03:00	-	-	-
04:00	-	-	-
05:00	-	-	-
06:00	-	-	-
07:00	-	-	00:58:57
08:00	00:06:11	00:38:08	-
09:00	-	-	-
10:00	-	-	-
11:00	00:06:27	-	-
12:00	-	-	01:13:31
13:00	00:05:48	00:38:42	00:59:39
14:00	00:06:53	00:36:00	-
15:00	-	00:38:55	01:02:19
16:00	00:06:15	00:39:12	01:00:39
17:00	-	00:40:43	-
18:00	00:05:45	00:42:47	01:13:52
19:00	00:06:38	00:44:05	-
20:00	00:09:25	-	-
21:00	00:07:32	-	01:06:29
22:00	-	00:46:25	00:46:25
23:00	-	-	-

The tables provide quite detailed information on travel times between the different sites. By analysing the raw data further in discrete time periods, it is possible to derive very detailed information.

In addition, unlike traditional travel time surveys, the information can provide information for weekend and overnight situations, something not available previously.

6. Discussion

6.1 Summary of Results

Bluetooth surveys were carried out for a full seven day period.

The system generates a considerable amount of data which is collated, processed and presented in the web-based reporting and analysis tool.

Further, more detailed, analysis also can be carried out using the raw (but still encrypted) data which can be output in MS Excel format.

6.2 Lessons Learned

Bluetooth surveys are still relatively new. They offer a valuable development in traffic survey techniques available to the transport planner. There is the potential to capture a significant amount of information at relatively low upfront cost.

As with all traffic survey techniques, Bluetooth survey techniques are not without their foibles. The user should not have unrealistic expectations of Bluetooth survey techniques and should be aware of the system's capabilities when defining the survey programme.

Some of the issues which came to light during the surveys and when analysing the data are discussed below.

Firstly, users should be aware that Bluetooth surveys will not provide the classification or the direction of travel for each Bluetooth record.

The classification of each record can be achieved by cross reference with the video survey data but it is essential that the Bluetooth and video surveys equipment are synchronised with the same time stamp.

Although the direction of travel is implied in the matching process, it can sometimes be difficult to be certain. Users might consider installation of two detectors working in series at each station, referred to as 'super-sites.'

Depending on location, each survey station will capture Bluetooth signatures from all passing devices whether they subsequently pass through further stations or not. Many of the records will be associated with local trips, including passing pedestrian movements. Consequently, a number of records will remain unmatched.

Similarly, a number of records could be matched for trips to and from the same station. These are perfectly valid movements and could be attributed to vehicles making valid u-turn manoeuvres, or 'out and back' type trips. The user should consider each of these movements carefully before using the information in the dataset.

It is also important to consider setting a journey time validity matrix when matching trips between stations, particularly for stations that are far apart. The user should be clear about the what represents a reasonable journey time between stations.

Because of the distances involved, the A77(T) data for example returned some excessive journey times between stations. This was later identified as multipurpose trips where for example a delivery vehicle might make several stops whilst travelling between survey stations.

In analysing the datasets, it is essential to remember that the detectors capture signatures from Bluetooth *devices*. It is not implicit that the device is a vehicle. It could be a Bluetooth device in a vehicle or the signature from a Bluetooth device fitted to a vehicle. Equally, it could be a pedestrian walking past the survey station.

The cordon used on the initial A77(T) surveys was not complete in the sense that there were gaps for the traffic 'disappear' unseen. The station at Stranraer West (access into Stena terminal for cars) returned a high number of single signatures i.e. the signature was captured once only. This is to be expected within a town centre location but it was compounded when it was realised the station was located opposite a petrol filling station. Users should consider very carefully where the survey stations are mounted.

It is also perfectly feasible for the device to be to be active as it passes one station but then inactive, for whatever reason, before passing the next scanning unit. The user may have switched off the Bluetooth capability.

It is possible for the survey station to miss the device together at the next station. This can be an issue where the device might be detected at either end stations but not at intermediate stations. This is not necessarily a missed record. Users should consider alternative routes that could be used to make the same trip.

6.3 Journey Time Data

Bluetooth data is particularly useful for collecting journey time information along a route. The data collected as part of the A77(T) surveys has been shown to provide a good sample of the total trips passing each scanning location.

Once matched at other points along the route, the information provides a dataset of journey times between these points at various times of the day, which otherwise would be time consuming, difficult and expensive to collect using traditional moving observer methods.

6.4 Web-Based Reporting and Analysis Tool

Bluetooth MAC data from each scanning unit was uploaded by GPRS to Sky High's web hosted server where it was processed. The data was screened for multiple devices passing the same point at the same time before being published to a web based reporting suite.

Initially, Sky High passed the summary information to SIAS, where a 2hr journey time filter had been applied to all matched records. Subsequent checks suggested that more detailed journey time information was required so Sky High were able to supply the raw datasets to SIAS.

In general, the overall 24hr number and distribution of matched devices output from the webhosting service produced similar results to that analysed by SIAS. However, some differences remained when considering individual Origin and Destination pairs, and again for the hourly comparison and average journey time assessments.

While the web hosting service provides an overview of matched devices, users should consider the objectives of their survey and whether more detailed information could be realised by examining the raw datasets.

7. Summary and Conclusions

7.1 Summary

Transport Scotland engaged consultants SIAS Ltd and Sky High Traffic Surveys to collect evidence to determine any change in traffic patterns as a result of Stena's move to Old House Point.

Unlike more traditional survey techniques for capturing origin-destination movements, Transport Scotland opted for Bluetooth survey techniques, with traffic surveys carried out prior to the relocation of the port in November 2011.

Analysis of the datasets suggests an initial sample rate of around 49% based on a comparison. If the sample is derived from the number of matched records, then the sample rate from the A77(T) data is around 21%. Further analysis of raw datasets suggests a sample of around 18% of the total number of records being matched.

A detailed matching process allowed SIAS to derive origin destination matrices for different day types and time period. Importantly, it allowed a feel of the level of long distance trips using the route. This information will be used to help inform a microsimulation traffic model of the route.

A significant amount of journey time data was also derived. Traditionally, this sort of information would take time to collect. However, Bluetooth techniques now offer the ability to collect journey time information readily and easily.

7.2 Conclusions

Transport Scotland took the opportunity to trial Bluetooth surveys on the A77(T). The technology is still fairly new and Sky High continue to develop the data capture and processing aspects of the service. Through detailed analysis of the survey data, SIAS has identified a number of nuances with the technique, many of which can be addressed through careful consideration of the survey specification. SIAS and Sky High worked together to resolve the various issues as they arose. As a result a number of lessons have been learned.

Advantages to this type of survey include the data being collected in a non intrusive manner, the data remains anonymous and a single recording device covers multiple lanes. The data can be accessed live while remaining anonymous and days worth of data can be collected.

Disadvantages include a sample size dependent largely on whether each individual vehicle has within it an active Bluetooth device and external interference from other Bluetooth devices in nearby areas ('background noise'). A further disadvantage is that vehicle class and direction of travel are not recorded at each site. Video or classified link counts should also be carried out.

Nevertheless, Bluetooth survey techniques offer a valuable addition in range of traffic survey techniques available to the transport planner. There is the potential to capture a significant amount of information at relatively low upfront cost. However, where Bluetooth surveys save considerable time and effort in establishing the survey itself, the user should allow sufficient time for post-survey data processing.

As with all traffic surveys, the information you get out of it depends on the effort you put in at the start.